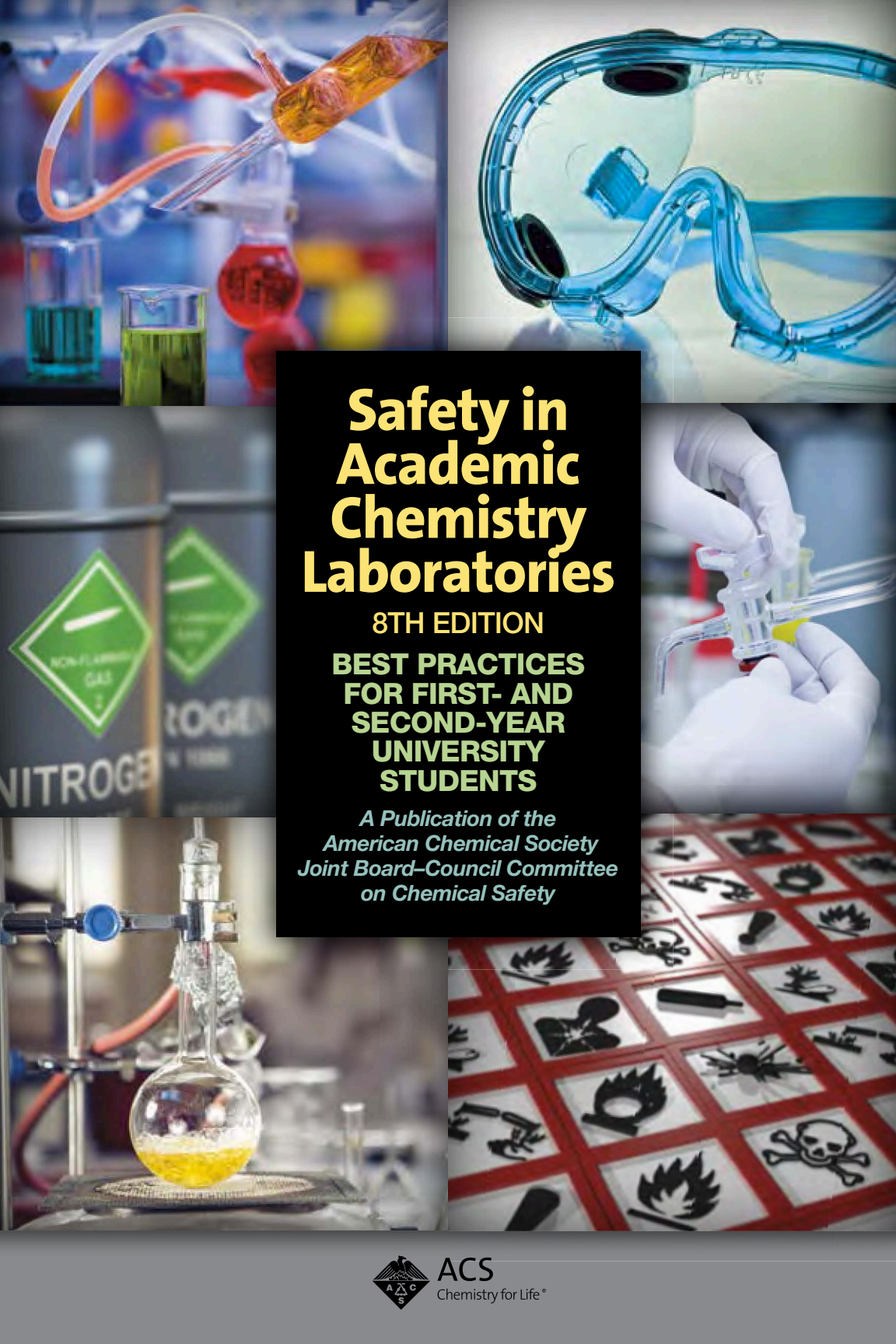


Safety in Academic Chemistry Laboratories

8TH EDITION

BEST PRACTICES FOR FIRST- AND SECOND-YEAR UNIVERSITY STUDENTS

A Publication of the American Chemical Society Joint Board–Council Committee on Chemical Safety

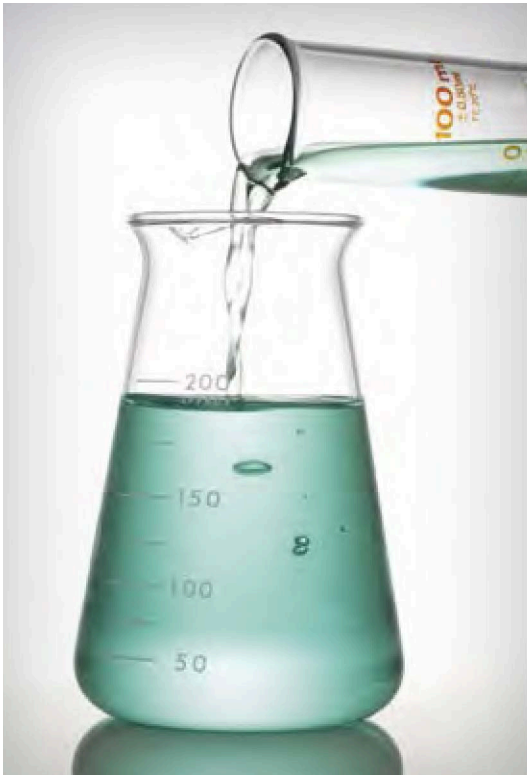
ACS Chemistry for Life®

CHAPTER 1

Being Safe in the Laboratory

Introduction

Chemistry laboratories present more hazards than are typically found in other science laboratories. Interestingly, the very properties that we value in some chemicals are also what make them hazardous. For example, we like the fact that some organic solvents dissolve organic molecules very nicely, but this same feature also makes them dry out our skin. We use the reactivity that acids and bases provide in order to effect a chemical change, but that reactivity also makes them hazardous if they are in contact with skin or are ingested. We like the fact that liquid nitrogen and dry ice are both *very* cold, because sometimes we need very low temperatures, but these substances are dangerous to handle with bare hands precisely because they are so cold. We like the fact that natural gas burns (in a Bunsen burner), but if it builds up in an enclosed space, a spark or flame can cause an explosion.



In any laboratory—a chemistry laboratory or other science laboratory—where chemicals are used, there will be hazards. Well-educated chemists and well-educated chemistry students need to understand the hazards of chemicals and of various chemical procedures in order to work safely in the laboratory. For the ability to work safely, it is key to not only recognize a hazard but also assess the actual risk it poses. For example, an organic solvent might be very

flammable, but the risk in a particular laboratory is low if the solvent is well contained in a bottle or if the amount of solvent is very small and sources of ignition are excluded from the area. Similarly, a chemical might be very toxic by ingestion, but if we avoid conditions where it would be ingested, the risk is low. Finally, a strong acid might be very corrosive to the skin, but if we take steps to avoid skin contact, the risk is lower. *In chemistry laboratories, there are always some hazards and some risks.* One goal of this booklet is to help you learn how to recognize hazards and how to minimize risks.

Your instructor is requiring you to read this booklet so that you can work safely in laboratories with chemicals. Conducting chemistry experiments can be fun, intellectually satisfying, and productive – but only if these experiments are conducted as safely as possible. At the end of each day in the laboratory, the goal is for you to go home just as you came – with no injuries or illnesses as a result of your laboratory experience.

In order to work safely in your first laboratory courses, you will learn lots of rules about chemicals and how to handle them. Indeed, this booklet is full of rules, too. But there are *principles of safety* (RAMP) behind all of these rules, and learning these principles is also a goal of this booklet. The rules in this booklet deal with many situations that you will encounter in first- and second-year chemistry courses. But there are many additional hazards that you may encounter in more advanced courses and in research projects. So, while learning some rules, you should also start to develop principles and concepts about safety that can be applied in your future working life, even though you might not be working specifically in a chemistry laboratory. For non-chemistry science majors, your "non-chemistry" laboratories will often use chemicals. As the saying goes, "The chemicals don't know what laboratory they are in." Many chemicals are used in the home also, so handling and using chemicals safely has a broad range of application.

RAMP Up for Safety

Let's take this idea of risk management further and develop a model for how to always work as safely as possible in the laboratory. A simple paradigm for working safely in the laboratory is:

Recognize hazards.

Assess the risks of hazards.

Minimize the risks of hazards.

Prepare for emergencies.

This is known as RAMP,[1] because of the verbs in the four statements. It is easy to remember and is a key to creating a safety culture in experimental work in chemistry.

Learning to recognize hazards is one of the main goals of this booklet. In Chapter 3, you will learn about categories of hazards and general features of these hazards. Assessing and minimizing risk are also discussed, to help you learn how to work safely when dealing with inherently hazardous compounds or procedures.

Finally, there are a handful of reasons why adverse incidents might occur in the laboratory, so it is wise and prudent to be ready for emergencies. If you follow this RAMP protocol in all of your laboratories and for all of your experiments, the likelihood of injury or illness is very low – probably virtually zero. In fact, because of good safety education, these inherently hazardous environments are actually very safe places to work.

[1] *RAMP is presented and discussed further in: Hill, R. H.; Finster, D. C.* Laboratory Safety for Chemistry Students, *2nd ed.; John Wiley & Sons: Hoboken, NJ, 2016.*

Safety in Academic Chemistry Laboratories is designed for use as an aid in teaching safety during the first two years of chemistry courses. In these early years, most laboratory experiments will have been carefully reviewed for safety by your institution's chemistry faculty. The risks of these experiments have been minimized, and there is considerable oversight of these early laboratory sessions.

■ IN YOUR FUTURE: Learning More about RAMP

After these first two years, you will participate in more advanced laboratories, which provide more latitude for independent learning. These advanced laboratory sessions will require you to be more responsible and to learn more about laboratory hazards and risks. You will need to incorporate more diligently the principles of safety: to recognize hazards, assess and minimize the risks of hazards, and always be prepared for emergencies. The RAMP principle can be applied to your everyday life, too!

Safety Culture and Your Role in It

The safety knowledge and skills that you learn in your chemistry courses is greatly influenced by the safety culture of your institution. The components of a strong safety culture require *you* to do your part. There are four areas that should receive your attention: leadership, learning safety, building a positive safety attitude, and learning lessons from safety incidents. You can learn much more about safety culture by reading *Creating Safety Cultures in Academic Institutions*.[2]

Leadership plays a critical role in the kind of safety culture an institution will have. Although you may have no role in the leadership of your institution, you *do* have a role in being a personal leader in safety. As in other aspects of life, safety is encouraged by good example. You can show your leadership by following the safety instructions given to you by your instructors, by always wearing your required personal protective equipment (such as safety goggles, gloves, and a laboratory coat), by reporting all safety incidents (however minor), and by taking time to consider the risks involved in an experiment.

As you learn chemistry, you will be learning about laboratory and chemical hazards and how to minimize the risks of those hazards in the laboratory — elements of laboratory safety. It is crucially important to your personal safety (and to the safety of others) that you really try to learn about and to understand hazards in the laboratory. This understanding can save you or others from injuries or other adverse incidents. Understanding *why* chemicals or situations are hazardous is a critical part of learning to be safe. For example, if you know *why* something is flammable, you will be better able to work with flammable materials in the future. As you learn chemistry, you should endeavor to learn as much about safety as you can. We hope that you will be learning about safety throughout your entire undergraduate experience and will not view safety as just a set of rules to memorize. A safety education involves building a substantial knowledge of the various chemical and laboratory

hazards, learning how to evaluate the risks of those hazards, learning how to minimize the risks of all the hazards you may encounter, and being prepared for emergencies that might arise during laboratory work with these hazards — we're talking about RAMP here.

If you continuously learn about safety during your undergraduate years of education, and its importance is constantly reinforced, you should be building a positive safety attitude, sometimes called a safety ethic. If you always take time to review the hazards and safety measures of each and every experiment, then you will also be maintaining your positive safety attitude. The proper attitude for safety is reflected in *the safety ethic:* value safety, work safely, prevent at-risk behavior, promote safety, and accept responsibility for safety.[3] A positive safety attitude will likely be expected and required by your future employer.

Finally, although we all strive to keep everyone safe in our laboratory operations, adverse safety incidents can sometimes happen. Much of what is known about safety has been learned from mistakes or incidents. When these happen — even minor incidents — they need to be shared so that we can all learn lessons from the missteps that were made. Sharing these incidents should always be done in a nonpunitive way. Learning lessons is an important part of our work as scientists, so keep this in mind as you learn about chemistry and safety.

As you can tell by this introductory chapter, safety plays a key role in chemistry. Safety concerns apply across all chemistry and related fields, and safety is in fact a discipline of chemistry, just like inorganic, organic, analytical, physical, or biological chemistry. Everyone using chemistry in their career needs adequate knowledge, skills, and attitudes about safety to work safely in a laboratory. *Keep safety at the forefront in your chemistry and science education, and it will serve you well.*

SUMMARY

Working in laboratories requires that you learn to apply the RAMP concept: Recognize hazards, Assess the risks of hazards, Minimize the risks of hazards, and Prepare for emergencies. Learning the *why* about hazards, their risks, and procedures and processes designed to protect you is the basis for safety rules. If you understand *why*, you are more likely to follow safe procedures and safety rules.

REFERENCES

[1] Hill, R. H.; Finster, D. C. *Laboratory Safety for Chemistry Students*, 2nd ed.; John Wiley & Sons: Hoboken, NJ, 2016.

[2] ACS Joint Board–Council Committee on Chemical Safety. *Creating Safety Cultures in Academic Institutions: A Report of the Safety Culture Task Force of the ACS Committee on Chemical Safety;* American Chemical Society: Washington, DC, 2012. www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/academic-safety-culture-report-final-v2.pdf (accessed March 6, 2017).

[3] Hill, R. H. The Safety Ethic: Where Can You Get One? *Chem. Health Safety.* 2003, *10*, 8–11. http://dx.doi.org/10.1016/S1074-9098(03)00025-X